Fundamentals & Basics of FCAW

1.0 INTRODUCTION:

Flux Cored Arc Welding (FCAW) is an arc welding process wherein the heat for welding is produced by an electric arc between a continuously fed flux-cored tubular electrode (wire) and the work piece (Figure 1). It is a variant of gas metal arc welding (GMAW) process. Shielding is provided either by the flux contained within (self-shielded FCAW) or may be supplemented with an external shielding gas (gas-shielded FCAW). The gas provides a protection of the arc and the weld pool from the contamination of nitrogen and oxygen in the atmosphere. The core ingredients in the conventional gas-shielded FCAW process act as slag formers, deoxidizers, arc-stabilizers and alloying additions. The FCAW process encompasses the benefit of continuous welding like solid wire & that of alloying & positional welding features through flux like manual metal arc welding.

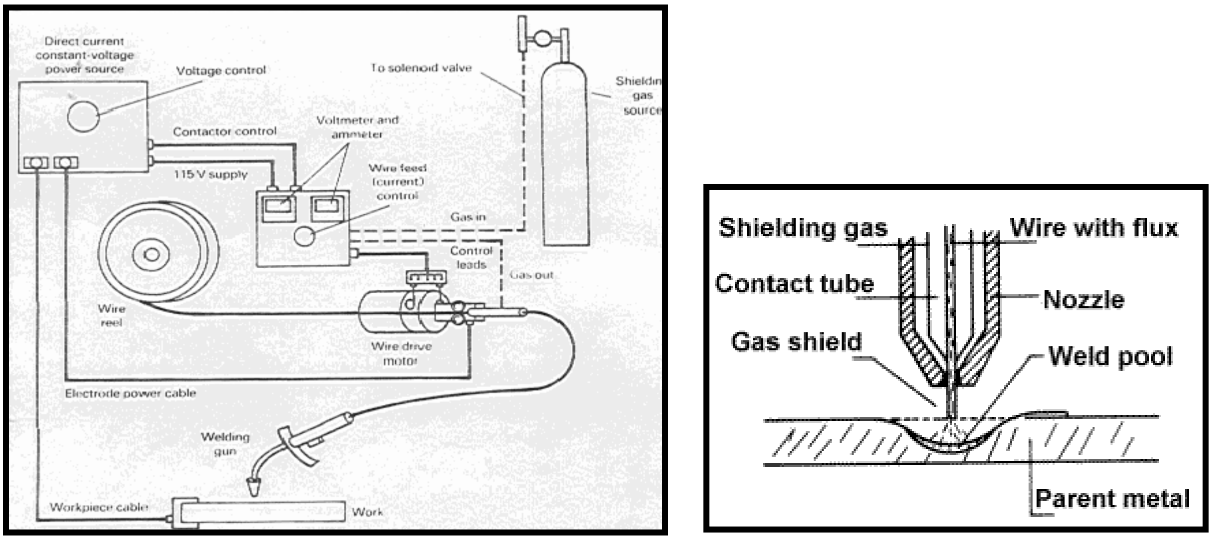

Figure-1: Schematic sketch of the flux-cored arc welding process and connections.

2.0 ABOUT THE PROCESS:

Shielding in gas shielded FCAW process is obtained from an externally supplied gas or gas mixture. A constant voltage, direct current power source (shown in figure-2) is most commonly accepted for FCAW process.

The welding procedures for FCAW welding are similar to those for other arc welding processes. Adequate fixturing and clamping of the work are required with adequate accessibility for the welding gun. Good connection of the ground lead to the work-piece or fixture is required. Location of the connection is important, particularly when welding ferromagnetic materials such as steel.

Figure-2: Photograph of welding machine and also the wire feeder.

The best direction of welding is away from the work lead connection.

The position of the electrode with respect to the weld joint is important in order to obtain the desired joint penetration, fusion, and weld bead geometry. When complete joint penetration is required, some method of weld backing helps to control it. A backing strip, porcelain strip or copper backing bar can be used. Backing strips and porcelain strips usually are disposable type whereas copper backing bars are removable & can be re-used.

The assembly of the welding gun should be done according to the manufacturer’s directions and the various parts & components are detailed in figure-3.

All gas and water connections should be tight; there should be no leaks. Aspiration of water or air into the shielding gas will result in erratic arc operation and contamination of the weld. Porosity may also occur.

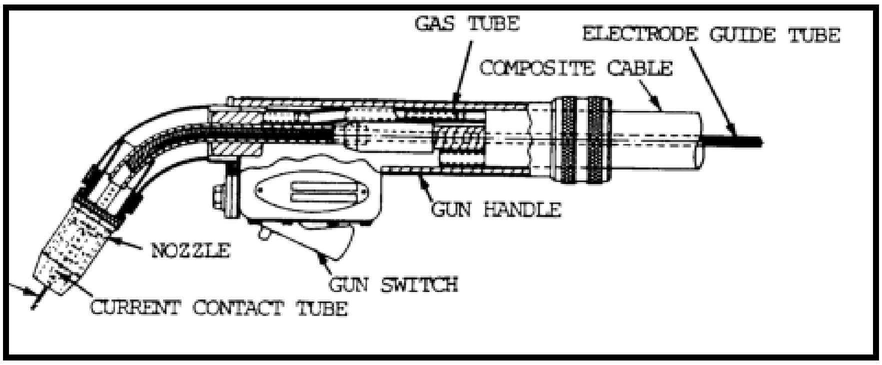

Figure-3: Schematic sketch of welding torch showing various parts & components.

The gun nozzle (figure-4) size and the shielding gas flow rate should be set according to the recommended welding procedure for the material and joint design to be welded.

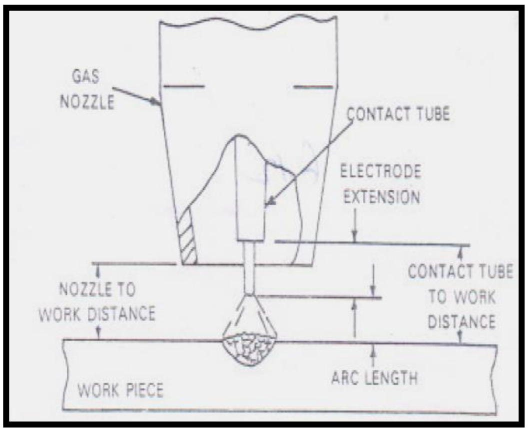

Figure-4: Schematic sketch of nozzle tip in FCAW process.

Joint designs that require long nozzle-to-work distances will need higher gas flow rates than those used with normal nozzle-to-work distances. When welding is done in confined areas or in the root of thick weld joints, small size nozzles are used.

The contact tube will wear with usage, and must be replaced periodically if good electrical contact with electrode is to be maintained and heating of the gun is to be minimized.

Electrode extension is set by the distance between the tip of the contact tube and the gas nozzle opening. The extension used is related to the type of MIG welding, short circuiting or spray type transfer. It is important to keep the electrode extension (nozzle-to-work distance) as uniform as possible during welding. Therefore, depending on the application, the contact tube may be inside, or extending beyond the gas nozzle.

The electrode feed rate and welding voltage are set to the recommended values for the electrode size and material. A trial bead weld should be made to establish proper voltage (arc length) and feed rate values.

Other variables, such as slope control, inductance, or both, should be adjusted to give good arc starting and smooth arc operation with minimum spatter. The optimum settings depend on the equipment design and controls, electrode material and size, shielding gas, weld joint design, base metal composition and thickness, welding position, and welding speed.

The wire feed & gas flow starts immediately as the power switch is on. But while stopping the operation, the wire feed rate should stop first (few seconds earlier) and then the gas flow rate. This sequence of functional activities during the welding operation is schematically shown in figure-5.

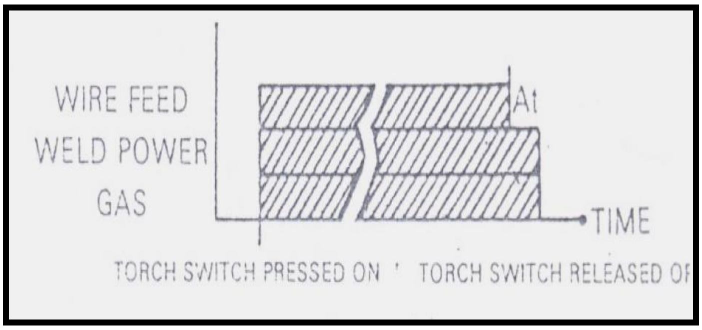

Figure-5: Graphical representation of functional operations in FCAW.

2.0 CLASSIFICATION SYSTEM AS PER AWS STANDARD (SFA 5.20)

E X X T – X M J H Z

(a) (b) (c) (d) (e) (f) (g) (h)

a) Indicates as an electrode (E).

(b) Indicates in 10 ksi (kilo-pound per square inch) increments, the minimum tensile strength of the weld metal produced by the electrode.

(c) Indicates the welding position of the designed electrode. (0)- flat and horizontal position, and (1)- for all positions.

(d) Indicates a flux-cored electrode.

(e) Indicates the usability and performance of the electrode 'G' indicates that the external shielding, polarity and impact properties are not specified. The 'S' indicates that the electrode is suitable for single pass alone (Table-1).

(f) M indicates that the electrode is classified using 75-80% argon/balance CO_2 shielding gas. In other cases, either carbon dioxide acts as shielding gas or the electrode is self-shielded.

(g) 'J' indicates the weld metal meets the impact toughness of 27 J at –40°C.

(h) Indicates the optional requirements of diffusible hydrogen in the deposited weld metal. H4, H8, H16 represents average maximum allowable diffusible hydrogen to be of 4, 8 and 16 ml/100 gm of weld metal respectively.

Table 1: Usability type designator for flux-cored electrodes

Type	Shielding	Single/ Multi-pass	Transfer mode	Impact toughness, J	Polarity	Special characteristics
T-1	Gas	Multi-pass	Spray-like	27 at –18°C	DCEP	Low spatter, full slag coverage
T-2	Gas	Single	Spray-like	Not required	DCEP	Low spatter, full slag coverage, high deoxidizers
T-3	Self	Single	Spray-like	Not required	DCEP	High speed
T-4	Self	Multi-pass	Globular	Not required	DCEP	High deposition, low penetration, crack resistant
T-5	Gas	Multi-pass	Globular	27 at –30°C	DCEP	Improved toughness, crack resistant, thin slag
T-6	Self	Multi-pass	Spray-like	27 at –30°C	DCEP	Improved toughness, deep penetration
T-7	Self	Multi-pass	Globular	Not required	DCEN	Crack resistant, good slag

						removal
T-8	Self	Multi-pass	Globular	27 at –30°C	DCEN	Improved toughness, crack resistant
T-10	Self	Single	Globular	Not required	DCEN	High speed
T-11	Self	Multi-pass	Spray-like	Not required	DCEN	General purpose
T-G	(a)	Multi-pass	(a)	Not required	(a)	(a)
T-GS	(a)	Single	(a)	Not required	(a)	(a)

(a) The corresponding parameters are not mentioned.

3.0 SELECTION OF PROCESS PARAMETERS:

A strict control over the welding parameters is mandatory for achieving quality and high-productive joint in both GMAW and FCAW processes. The characteristic features of each variable are summarized below.

3.1 Welding Current – The welding current is proportional to electrode feed rate provided the composition, diameter and extension of electrode remains unaltered.

1)	Deposition rate increases with increase in welding current.
2)	Increase in current increases weld bead penetration.
3)	A poor appearance and convexity of weld bead appears with excessive current.
4)	Insufficient current produces large droplet transfer and causes excessive spatter.

3.2 Arc Voltage – The arc voltage that is shown in the meter of the power supply is the sum of total voltage-drop in the welding circuit. This includes; the drop through the welding cable, the electrode extension, the arc, the work piece and the ground cable. Therefore, all other circuit elements are to be constant to obtain proportionate meter reading and arc voltage.

1)	Too high an arc voltage will result in excessive spatter and wide, irregularly shaped weld beads. A long arc gap during welding promotes more pick up of nitrogen from atmosphere. For mild steel it will result to form porosities and in stainless steels a lowering of ferrite content which in turn may cause for solidification cracking.
2)	Too low an arc voltage (too short an arc) will result in narrow and convex beads with excessive spatter and poor penetration.

3.3 Electrode Extension – The length of the wire extended beyond the tip of the nozzle to the arc pool is referred as the electrode extension. It affects the shielding conditions, arc energy, electrode deposition rate and weld penetration. Generally, an extension of 19 to 38 mm for gas shielded electrodes and approximately 19 to 95 mm for self-shielded electrodes can be applicable depending on the application.

1)	Longer arc extension results to form an unstable arc with excessive spatter. In gas shielded metal arc welding it results poor gas coverage of the weld pool resulting porosities and related defects.
2)	Too short an arc length is also undesirable due to excessive spatter.

3.4 Travel Speed – Heat input in the weld is inversely proportional to the arc travel speed. So, both too high and too low a travel speed is equally detrimental to the weld metal quality. It also results to form a poor bead appearance with a possibility of entrapped slag for higher arc travel speeds.

3.5 Shielding Gas Flow – The gas flow rate is an important factor to obtain a good quality weld joint. A poor shielding will result for a low gas flow rate, on the other hand too high a flow rate will create turbulence in the molten weld puddle causing porosities, slag entrapment and poor weld bead appearance. The correct gas flow rate should be selected on type and diameter of the gun nozzle, nozzle to work distance and rate of air flow in the vicinity of the welding operation.

3.6 Electrode Angle – The angle of the electrode determines the direction of arc force applied to the weld pool. Proper drag angle (between the weld axis and vertical plane) is maintained to achieve the desired weld penetration for thin or thick sections. Usually a lower drag angle (2° to 15°) is maintained for gas-shielded arc welding. The effectiveness of the shielding gas is lost with higher welding angle and generally it does not exceed 25°. For fillet welds in horizontal position, the liquid metal in the weld pool tends to flow in the welding direction as well as right angle to it. A work angle (between the axis and the vertical member) of 45° to 50° is thus used to counteract the flow in the latter direction.

4.0 WELDING TECHNIQUE:

Gun position or Welding technique usually refers the way in which the gun is hold in a position with respect to the work piece. Depending on the progress of travel the welding technique may either be a push technique, a drag technique or a perpendicular technique (Figure-6).

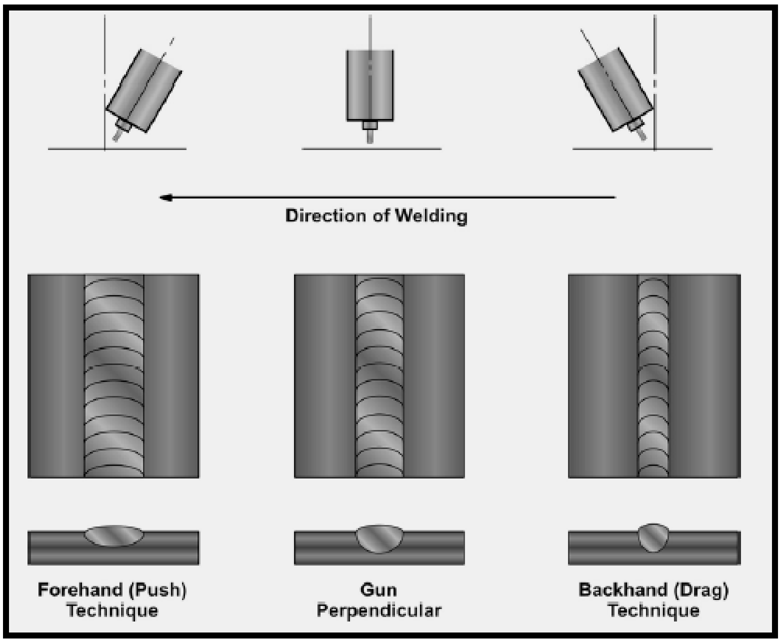

Figure-6: Schematic representations of various welding techniques.

Forehand technique is also referred as Push or Leading technique. The gun is pointed away from the weld puddle and is “pushed” away from the weld. Low penetration and faster travel speed facilitates this process as an advantage for thin sheet welding and for hard surfacing. Generally push technique offer a better view of the weld joint and the direction of wire into the groove.

In perpendicular technique the wire is fed straight into the weld instead of any angle.

A Backhand technique also sometimes is referred as, Drag, Pull or trailing technique. The bead in this technique becomes narrower and results more build up. Considering all the welding variables remaining same, the penetration obtained in this technique is more as the arc is directed towards a preheated base metal.